Loup River Basin

The Loup River Basin (Basin) is defined as the area of central Nebraska that drains into the Loup River above its confluence with the Platte River, Figure L-1. Major tributaries of the Loup River include Beaver Creek, the Calamus River, the Cedar River, the Dismal River, Mud Creek, the Middle Loup River, the North Loup River, and the South Loup River, Figure L-2. The total area of the Basin is approximately 15,200 square miles and includes all of Blaine, Grant, Greeley, Loup, Sherman, Thomas, and Valley counties and portions of Antelope, Arthur, Boone, Brown, Buffalo, Cherry, Custer, Dawson, Garden, Garfield, Hall, Holt, Hooker, Howard, Lincoln, Logan, McPherson, Merrick, Nance, Platte, Rock, Sheridan, and Wheeler counties. County seats in the Basin include Albion, Bartlett, Brewster, Broken Bow, Burwell, Columbus, Fullerton, Greeley, Hyannis, Loup City, Mullen, Ord, St. Paul, Stapleton, Taylor, and Thedford.

Sources of Water

Precipitation

Annual and growing season (May 1 through September 30) precipitation charts for gage sites in Arthur, Broken Bow, Greeley, Loup City, Ord, St. Paul, Taylor, and Valentine are shown on Figures L-3 through L-18. The average annual precipitation ranges from 18.3 inches at Valentine near the northwest end of the Basin to 25.8 inches at Fullerton in the southeast corner of the Basin. The average growing season precipitation ranges from 12.8 inches at Valentine to 16.9 inches at Fullerton. Locations of the precipitation gages can be seen in Figure L-19.

Ground Water

The hydrogeology of the Basin reflects the nature of the eolian and fluvial origin of the recent sediments. For purposes of this report, all saturated unconsolidated sediments of Quaternary age above bedrock inclusive of the paleovalley alluvial aquifers with

hydrologic connection, the alluvial and the shallow aquifers, and the bedrock Tertiary Ogallala Group are combined into the principal aquifer unit for the Basin (CSD 2005). Secondary aquifers are made up of the remaining bedrock aquifers. Tables L-1 and L-2 list the aquifers by age with the important hydrogeologic characteristics. The bedrock aquifers range in age from Tertiary to Cambrian, Figure L-20. The bedrock aquifers supply a small amount of water compared to the other aquifers but are an important source locally (CSD, 2005). They generally are not in hydrologic connection with the streams in the Basin.

The principal aquifer varies in saturated thickness from 0 to approximately 1,100 feet, Figure L-21. Depth to water from the land surface varies from 0 to more than 200 feet, Figure L-22 (CSD 2005). Transmissivity values range from less than 20,000 gallons per day per foot (gal/day/ft) to more than 250,000 gal/day/ft. Most areas of the Basin have transmissivity values between 100,000 and 150,000 gal/day/ft, Figure L-23. Specific yield ranges from less than 5 to greater than 20 percent, Figure L-24. The principal aquifer is generally unconfined and is in hydrologic connection with the streams (CSD 2005). The ground water table, Figure L-25, reflects the regional nature of the area where ground water tends to move from the uplands to the streams (CSD 2005).

Ground Water Use

Ground water in the Basin is used for a variety of purposes: domestic, industrial, livestock, irrigation, and others. There are a total of 15,824 registered ground water wells within the Basin as of October 1, 2005 (Department registered ground water wells database). Not all wells are registered in the Department database, especially stock and domestic wells, which if drilled prior to 1993 are not required to be registered. Certain dewatering and other temporary wells are not required to be registered. Irrigation is the largest consumer of ground water, with approximately 1,300,000 acres being supplied with water from approximately 10,000 wells as of October 1, 2005 (Department registered ground water wells database).

Ground water development is limited within the Basin by the geology and terrain of the area. Figure L-26 illustrates the location of depletive ground water wells. The areal extent of those wells indicates where ground water has been beneficially developed. The significant amount of well development in the east-central section of the Basin is due to the broad extent of the principal aquifer and the fact that much of the overlying land is suitable for irrigation. The western end of the Basin lies over the principal aquifer, but development in the west is limited because not all lands are suitable for irrigation. Ground water development analyzed by comparison of completion dates has shown that development of high capacity wells (depletive wells capable of pumping more than 50 gallons per minute) has been steadily increasing with accelerated increases during the years 1966 through 1981, Figures L-27, L-28, and L-29. Table L-3 shows the estimated average irrigated acreage by county within the Basin between 1950 and 2003. The increase in the number of other depletive wells seen in Figures L-28 and L-29 after 1993 is attributed to revision of the well registration statute in 1993.

Changes in Ground Water Table Elevation

Figure L-30 is a map made from a compilation of all ground water table elevations reported to the Conservation and Survey Division of the University of Nebraska-Lincoln in cooperation with the U.S. Geological Survey and the Natural Resources Districts. It shows an area in Custer, Buffalo, Howard and Merrick counties with declines of up to 20 feet in ground water table elevations from predevelopment through the spring of 2005. This area is adjacent to a similar area of decline in the Platte River Basin. There are large areas in Howard, Sherman, Greeley, Nance, Valley and Garfield counties in the eastern part of the Basin where the ground water level has risen. Parts of Hooker, Thomas, McPherson and Logan counties in the western part of the Basin also show rising ground water table elevations. Figure L-31 is the location map for selected ground water hydrographs across the Basin. Figures L-32 through L-37 are hydrographs (USGS 2005) which give a representative change in ground water table elevations for the particular area. Where possible a graph of a continuous recorder site is used.

Ground Water Management

The Basin primarily encompasses portions of two Natural Resources Districts (NRDs): the Upper Loup NRD (ULNRD) and the Lower Loup NRD (LLNRD).

The ULNRD has not established a ground water management area (GWMA), whereas the LLNRD has established a GWMA for quality purposes. As part of the GWMA requirements in the LLNRD, permits are required prior to the construction of wells pumping greater than 50 gallons per minute (gpm).

Surface Water

Hydrographs from eighteen surface water gages in the Basin are included in this report, Figures L-38 through L-55. They are Beaver Creek at Loretto and Genoa; Cedar River near Spalding and Fullerton; Dismal River at Dunning and near Thedford; Mira Creek near North Loup; Mud Creek near Sweetwater; Calamus River near Burwell and Harrop; South Loup River at St. Michael; Middle Loup River at Dunning, Arcadia, and St. Paul; North Loup River at Taylor, Ord and near St. Paul; and Loup River near Genoa, Figure L-56. Streamflow in the Basin is driven primarily by ground water discharge as baseflow to the streams with additional contributions from precipitation.

Surface Water Use

As of October 1, 2005, there are approximately 1,200 surface water appropriations in the Basin issued for a variety of uses. The majority of the surface water appropriations are for irrigation use and they tend to be located on the major streams. There are no instream flow appropriations in the Basin, but the instream flow appropriations on the Platte River below its confluence with the Loup River have a major impact on administration in the Basin. The first surface water appropriations in the Basin were permitted in 1890 and development has continued through present day. The largest period of development occurred in the 1970's with large increases in irrigated acreage occurring as additional

irrigation districts developed occurring at later dates, Figure L-57 and Figure L-58. The approximate locations of the surface water diversions are shown in Figure L-59. Information on specific surface water appropriations is available in the Department's biennial report. Information on categories of use can be found in Appendix H.

There are a number of surface water canals in the Basin. Annual surface water diversion records are presented in Figures L-60 through L-71 for the Burwell-Sumter Canal, Farwell Main Canal, Farwell South Canal, Middle Loup Canals 1-4, Mirdan Canal, Ord-North Loup Canal, Sargent Canal, Taylor-Ord Canal, and the Loup Power Canal.

Analyses for the Fully Appropriated Determination

Surface Water Administration

In the 115-year period since the first surface water appropriation was perfected in the Basin, there have only been a few recorded instances of surface water administration in the administrative record, with the first occurring after 1950. The amount of surface water administration in the Basin has increased significantly since 1998, when the instream flow appropriations were granted. Table L-4 shows the occurrences of water administration between 1985 and 2004. The junior surface water appropriations in the Basin had an average of 52.6 days in which surface water was available for diversion from July 1 through August 31 and 136 in which surface water was available for diversion from May 1 through September 30.

The senior surface water appropriation that caused all of the administration in the Basin has a priority date year of 1993; therefore it is necessary to reconstruct the water administration table pursuant to the methodology in Appendix D, Table L-5. Pursuant to the reconstructed table, there were an average of 37.2 days in which surface water was available for diversion from July 1 through August 31 and 112.6 days in which surface water was available for diversion from May 1 through September 30.

Table L-4. Water Administration in the Loup River Basin between 1985 and 2004.

Year	Water Body	Days	Closing Date	Opening Date
2000	Loup Basin	53	Aug 8	Sep 30
2001	Loup Basin	11	Aug 7	Aug 18
2002	Loup Basin	6	Jun 6	Jun 12
2002	Loup Basin	67	Jun 25	Aug 31
2002	Loup Basin	24	Sep 6	Sep 30
2003	Loup Basin	81	Jul 11	Sep 30
2004	Loup Basin	13	May 6	May 19
2004	Loup Basin	7	Jun 29	Jul 6
2004	Loup Basin	58	Jul 27	Sep 23

Table L-5. Reconstructed Water Administration Table, Loup River Basin, 1985 - 2004

Year	July 1 though August 31 Number of Days Available for Surface Water Diversion	May 1 through September 30 Number of Days Available for Surface Water Diversion
1985	44	130
1986	62	153
1987	47	138
1988	10	69
1989	14	47
1990	16	77
1991	6	66
1992	62	153
1993	62	153
1994	56	143
1995	52	134
1996	62	153
1997	40	131
1998	62	153
1999	61	152
2000	32	94
2001	28	111
2002	2	48
2003	6	72
2004	20	75
Average	37.2	112.6

Determination of Hydrologically Connected Area

No sufficient numeric ground water model is available in the Loup River Basin to determine the 10/50 area or the lag impact of ground water wells.

The 10/50 area was determined using the Jenkins methodology as explained in Appendix D. Figure L-72 shows the extent of the area considered to be hydrologically connected in accordance with Department rule 457 NAC 24.001.02 (Appendix A).

Lag Impacts

a) Current Well Development

The lag impact from depletive ground water wells was computed using the Jenkins methodology documented in Appendix D. The results show that an additional 95 cubic feet per second (cfs) of daily depletion can be expected from the Basin due to the effect of lag impact from existing wells. The total calculated future depletion at North Bend includes the future depletion from the Loup River Basin, and the Platte River Basin (see Lower Platte River Basin Chapter) and the total calculated future depletion at Louisville includes the future depletion from the Loup River Basin, Elkhorn River Basin (see Elkhorn River Basin Chapter), and the Platte River. The sum of those depletions results in a total depletion in the year 2030 of 110 cfs daily at North Bend and 310 cfs daily at Louisville if there is no new well development.

The results found by comparing the senior surface water appropriation with the depleted daily flows (see methodology in Appendix D) show that in the future the average annual number of days in which surface water will be available for diversion to the junior surface water appropriations in the Basin will be 34.7 days from July 1 through August 31 and 109.0 days from May 1 through September 30 (Table L-6).

Table L-6. Water Administration Table with Current Ground Water Depletions, Loup River Basin, 2011-2030

Year	July 1 though August 31 Number of Days Available for Surface Water Diversion	May 1 through September 30 Number of Days Available for Surface Water Diversion
2011	40	126
2012	59	150
2013	42	133
2014	6	64
2015	14	46
2016	14	75
2017	4	64
2018	61	150
2019	62	153
2020	51	136
2021	51	133
2022	62	153
2023	38	129
2024	61	150
2025	61	152
2026	26	87
2027	20	97
2028	1	44
2029	5	71
2030	16	67
Average	34.7	109.0

b) Future Well Development

Estimates of the number of high capacity wells that would be completed over the next 25 years if no new legal constraints on the construction of such wells were imposed were calculated based on extrapolating the present day rate of increase in well development into the future, Figure L-73. For the past 20 years, the rate of increase in high capacity wells is nearly linear at a rate of 114 wells per year.

The lag impact was computed for the projected wells using the Jenkins methodology documented in Appendix D. The results show that an additional 220 cfs of daily depletion due to ground water pumping can be expected from the Basin if there is new well development.

The result of the future development depletions can be quantified the same way as with the current depletions. The sum of the depletions with future development results in a total depletion in the year 2030 of 270 cfs daily at North Bend and 530 cfs daily at Louisville.

The results found by comparing the senior surface water appropriation with the depleted daily flows show that in the future, with no restrictions on well development, the average annual number of days in which surface water will be available for diversion to the junior surface water appropriations in the Basin will be 33.1 days from July 1 through August 31 and 105.5 days from May 1 through September 30, Table L-7.

Table L-7. Water Administration Table with Current and Future Ground Water Depletions, Loup River Basin, 2011-2030

Year	July 1 though August 31 Number of Days Available for Surface Water Diversion	May 1 through September 30 Number of Days Available for Surface Water Diversion
2011	39	123
2012	56	147
2013	39	130
2014	5	60
2015	14	44
2016	11	72
2017	3	63
2018	59	142
2019	62	153
2020	47	127
2021	49	126
2022	61	152
2023	38	129
2024	61	146
2025	61	152
2026	20	81
2027	15	89
2028	1	42
2029	4	69
2030	16	62
Average	33.1	105.5

Future Surface Water Development and Uses

The number of surface water appropriations in the Basin has grown steadily over the past 30 years and it appears appropriate to project that that trend will continue into the future, Figure L-57. The number of acres permitted for surface water irrigation has also grown significantly during the past 30 years as additional irrigation districts lands have been developed Figure L-58. However, surface water development must be limited to ensure compliance with the Nebraska Nongame and Endangered Species Conservation Act (NNESCA) due to the presence of Pallid Sturgeon and Sturgeon Chub in the Lower Platte River. The Department and the Nebraska Game and Parks Commission have a policy regarding the procedure for issuing new surface water appropriations and amending existing appropriations so that NNESCA will be complied with. This policy limits the number of surface water appropriations that can be issued without further study of the effects on these species.

Ability to Satisfy Net Corn Crop Irrigation Requirement

Figure L-74 shows the net corn crop irrigation requirement for the Basin. The map shows the net corn crop irrigation requirement to range from approximately 13.5 inches in the western portion of the Basin to less than 8.0 inches at the confluence of the Loup and Platte Rivers. Assuming a surface water diversion rate equal to 1 cubic foot per second per 70 acres and a downtime value of 10 percent; depending on the location in the Basin, it takes between 21.2 days and 35.9 days annually to divert 65% of the net corn crop irrigation requirement from July 1 through August 31 and between 27.8 days and 46.9 days to divert 85% of the net corn crop irrigation requirement from May 1 through September 30. The junior surface water appropriation in the Basin with the highest net corn crop irrigation requirement is located along the South Loup River in Custer County. Comparing its location with the data in Figure L-74 shows that its net corn crop irrigation requirement would be approximately 11.6 inches annually. For an 11.6 inch net corn crop irrigation requirement it would take 30.8 days to meet 65% and 40.3 days to meet 85% of the net corn crop irrigation requirement.

The reconstructed surface water administration analysis showed surface water was available for diversion an average of 37.2 days from July 1 through August 31 and an average of 112.6 days from May 1 through September 30. The number of days in which surface water was available for diversion in both the July 1 through August 31 and the May 1 through September 30 time frames exceeds the number of days surface water is required to be available for the greatest net corn crop irrigation requirement for the junior surface water appropriations in the Basin during those same periods.

Sufficiency of Surface Water Supply [Nebraska Revised Statutes Section 46-713(3)(a) (Reissue 2004)]

The average number of days in which surface water was available for diversion in both the July 1 through August 31 and the May 1 through September 30 time frames required by Department rule 457 Nebraska Administrative Code (NAC) 24.001.01 exceeds the number of days surface water is required to be available pursuant to the rule during those same periods. The lag impact analyses show that even in the future, the number of days in which surface water will be available for diversion in both time periods will exceed the number of days surface water would be required to be available. Table L-8 summarizes the results of comparisons between the number of days surface water must be available to meet the 65% and 85% net corn crop irrigation requirements and the number of days in which surface water was available for diversion to the junior surface water appropriations.

Table L-8. Summary of Comparison Between Net Corn Crop Irrigation Requirement and Number of Days Surface Water is Available for Diversion.

	Number of Days Necessary to Meet the 65% and 85% of Net Corn Crop Irrigation Requirement	Average Annual Number of Days Available to the Junior Surface Water Appropriations (1985-2004)*	Average Annual Number of Days Available in 2030 with no Additional Well Development	Average Annual Number of Days Available in 2030 with Additional Well Development
July 1 – August 31	31.9	37.2 (5.3 days above the requirement)	34.7 (2.8 days above the requirement)	33.1 (1.2 days above the requirement)
May 1 – September 30	41.7	112.6 (70.9 days above the requirement)	109.0 (67.3 days above the requirement)	105.5 (63.8 days above the requirement)

* From the reconstructed administration record.

Sufficiency of Streamflow for Ground Water Supply [Nebraska Revised Statutes Section 46-713(3)(b) (Reissue 2004)]

Since the criteria for Nebraska Revised Statutes Section 46-713(3)(a) were satisfied, the conclusion for this section is the same for reasons explained in the report introduction.

Sufficiency of Surface Water Supply for Compliance with Compacts or State Laws [Nebraska Revised Statutes Section 46-713(3)(c) (Reissue 2004)]

There are no compacts on any portions of the Loup River Basin in Nebraska. At this time there is sufficient water supply in the Basin to comply with NNESCA and, as discussed above, future development will be limited so as to continue compliance.

Future Development of Surface and Ground Water [Nebraska Revised Statutes Section 42-713(1)(b) (Reissue 2004)]

Given the rate of registered ground water well and surface water appropriation development, the conclusion that the Basin is not fully appropriated would not change even if no additional legal constraints were placed on development and a reasonable

projection of a continuation of the current trend of well development of the last 20 years is used.

Conclusions

There is no evidence that current ground water depletions to streamflow in the Basin are affecting surface water users sufficiently to meet the criteria for being fully appropriated as found in Department rule 457 NAC 24.001.01 when compared to the amount of surface water available at the present time.

There is no evidence available at this time that lag impact will be sufficient in 25 years to affect existing water users enough to meet the criteria for being fully appropriated as found in Department rule 457 NAC 24.001.01.

Based upon available information and its evaluation, the Department has reached a determination that the Basin is not fully appropriated. The Department has also determined that even if no additional legal constraints are imposed on future development of hydrologically connected surface water and ground water and reasonable projections are made about the extent and location of future development, this conclusion would not change.

The Department determination may change in future years to be preliminarily fully appropriated for the Basin if one of the following occurs:

- A surface water appropriation is issued in an area where the net corn crop irrigation requirement is greater than 12.4 inches.
- The subsequent analysis year is drier than the first year used in the surface water administration analysis. For example, 2005 was considerably drier than 1985 when comparing Platte River flows. The preliminary data shows that 2005 had 32 fewer days when the instream flow appropriation were met at North Bend. That alone will reduce the 20-year average number of days in which surface water was available for diversion by 1.6 days.

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